UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

SOIL SALINITY MANAGEMENT - NONIRRIGATED (ACRE)

CODE 571

MONTANA TECHNICAL GUIDE **SECTION IV**

DEFINITION

Management of land, water, and plants to control harmful accumulations of salts on the soil surface or in the root zone on nonirrigated areas.

PURPOSE

Treatment ***and prevention*** of saline or sodic-affected areas on nonirrigated land to permit desired plant growth and protect surface and ground water resources.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all nonirrigated land where (a) human-induced soil salinity or sodicity is at or approaching a level that adversely affects land use, or (b) combinations of factors - topography, soils, geology, precipitation, and land use - indicate the future probability of such adverse effects. ***This standard establishes the minimum acceptable requirements for the planning, design, operation, and maintenance of interrelated practices used to remedy and control the formation of saline or sodic areas.***

CRITERIA

Salinity is the concentration of dissolved mineral salts present in waters and soils. The major solutes comprising dissolved mineral salts are the cations Na, Ca, Mg, and K and the anions Cl, SO4, HCO3, CO3, and NO3. Other constituents that may contribute toward salinity in waters include B, Sr, Li, SiO2, Rb, F, Mo, Mn, Ba, and Al. The original, and to some extent, the direct source of all the salt constituents are the primary minerals found in soils and in the exposed rocks of the earthís crust. Although weathering of primary minerals is the indirect source of nearly all soluble salts, there are probably few instances where sufficient salts have accumulated in place from this source alone to form a saline soil. Saline soils usually occur in areas that receive salts from other locations, and water is the primary carrier.

<u>Restricted drainage</u> is a factor that usually contributes to the salinization of soils and may involve the presence of a high groundwater table or low permeability of the soil. The high groundwater table is often related to topography.

Due to the low precipitation in arid regions, surface drainageways may be poorly developed. As a consequence, there are drainage basins that may have no outlet to permanent streams. Under such conditions upward movement of saline groundwater or evaporation of surface water results in the formation of saline soil. The extent of saline areas thus formed may vary from a few acres to hundreds of square miles.

<u>Low permeability</u> of the soil causes poor drainage by impeding the downward movement of water. Low permeability may be the result of an unfavorable soil texture or structure or the presence of indurated layers (claypans, caliche layer, or silica hardpans).

NOTE: This type pf font ((**AbBbCcDdEe 123..**) indicates NRCS National Standards.
This type of font ***(AaBbCcDdEe 123..)*** *indicates Montana Supplement.*

ON ALL LANDS:

1. Correct the salinity problem by applying the practice(s) as part of an overall resource management system (RMS).

2. Planned actions should give first consideration to prevention rather than correction.

3. To the maximum extent practical, use vegetation to utilize soil water in the recharge areas.

4. When subsurface drains are needed, the configuration selected will give priority consideration to placing interceptor drains close to the recharge area to maximize the benefited area and provide a drain effluent of the best possible water quality.

5. Where applicable, improve surface drainage in the recharge area.

6. Corrective measures must comply with water quality laws and regulation. Monitoring of before and after conditions may be recommended.

7. List plants and provide management details on the plants adapted for use in recharge and affected area. Consider factors such as water usage, salt tolerance, and erosion control characteristics.

8. Incorporate, by reference, appropriate conservation practices that constitute components of the treatment of recharge and affected areas.

9. List the types and extent of environmental and ecological monitoring and evaluation that may be necessary.

10. Identify the seep- or salt-affected area. Early detection and diagnosis of a problem area are important in designing and implementing control and reclamation practices to prevent further damage.

SALINE SOILS

VISIBLE DETECTION

Some visible symptoms of impending saline seep development are listed as follows:

1. Certain weeds and native plants are commonly found on salt-affected soils and are indicators of seep areas (see Table 1, Native Plants and Introduced Weeds Found on Salt-Affected Areas). Kochia can be an indicator plant on cultivated land. Kochia growing vigorously after grain harvest, in small areas where normally the soil would be too dry to support weed growth, is an indicator. Examine these areas to see if the subsoil is wet.

2. Scattered salt crystals on a dry soil surface.

3. Prolonged soil surface wetness in small areas following a substantial rain. There will normally be uneven surface drying following a rain, but if a local area remains wet two to four days longer than the rest of the field, it may indicate a shallow water table. A soil moisture probe may show that the soil is unusually wet or that there is free water present.

4. Tractor wheel slippage or tractor bog-down in certain areas. Water often seeps into the wheel tracks and remains for a period of time. Salt crystals form on soil surface as the discharge area dries.

5. Excessive small grain vegetative growth accompanied by lodging in localized areas that produced normal growth in previous years. Reports may include crop yields that are unusually high. Such areas may be subirrigated by a rising water table, but the salt content is not yet high enough to reduce growth. These wet areas may become salinized and often expand quickly.

6. Foxtail barley infestations that increase with time may be another indicator. In a normally developed seep, the sequence of vegetation going from the center to the perimeter is bare soil, foxtail barley, and kochia. After several years, the kochia may move inside the foxtail barley area.

See Table 1 on Page 3 (Continued)

Table 1. Native Plants and Introduced Weeds Commonly Found on Salt-Affected Areas

Common Name	*Level of Salinization*
curley dock	
poverty weed	
kochia	*moderate*
plains bluegrass	
alkali cordgrass	
slender wheatgrass	
spear saltbush	*high*
alkali bluegrass	
alkali sacaton	
foxtail barley	
greasewood	
Inland saltgrass	
Nuttallís alkaligrass	*very high*
shore arrowgrass	
red grasswort	
seepweed	

7. Trees stunted or dying in a shelterbelt or windbreak. Leaves often turn light green or yellow.

8. Sloughed hillside, covered by native vegetation, adjacent to a cultivated field.

9. Other symptoms, including poor seed germination and abnormally mellow, dark-colored surface soil on lower slopes. The dark color would be caused by dispersed lignite or organic matter mixed with surface soil.

10. Electrical Conductivity (EC) measurements may be taken to identify and confirm an encroaching or developing saline seep. Soil salinity may be low near the soil surface, but increases considerably in the one to three foot soil depths.

IDENTIFY THE RECHARGE AREA

1. After the seep has been identified, the next step is to locate the recharge area. Most treatments for controlling the salt-affected area must be applied in the recharge area, which will normally be at a higher elevation than the discharge area. The recharge area must be accurately determined if treatment is to be successful. The recharge area may be located directly upslope or at an angle across the slope from the discharge area. Methods for determining the location and size of the recharge areas are only approximate. Following are some methods of recharge area identification:

a) <u>Soil Survey</u>. Soil surveys may be used to locate gravelly or sandy soil areas upslope from the salt-affected area. These areas usually serve as recharge areas and should be examined carefully. Areas of 0 to 2 percent slope and poorly drained areas (depressions and closed basins) may also be recharge sites.

b) <u>Soil Probe</u>. Recharge areas can often be located by probing the area upslope from the seep with a soil probe (i.e., Paul Brown Probe). Upslope areas with soil wet to more than 40 inches are potential recharge areas. Deeper probing to six feet or more provides further assessment of the extent of the recharge area. If the upslope area is uniformly wet to more than 40 inches, the probe procedure should not be used to detect recharge areas during that particular season. If a seep is surrounded by higher topography on several sides, the soil probe can be used to identify direction of recharge area from the seep. For example, if the soil is abnormally wet in one direction, this indicates the potential recharge area.

c) <u>Inductive Electromagnetic Soil Conductivity Method (EM 31 or EM 38).</u> These instruments provide relative readings of electroconductivity of a soil and must be calibrated to obtain accurate EC measurements.

d) <u>Drilling (auger or core).</u> Based on aerial photos and field observations, several holes are drilled in both the *discharge and the suspected recharge areas. Wells are carefully logged noting depths to dense (clay and shale) and highly permeable (sand, gravel, and lignite) zones. Depth to free water should also be noted. These wells will identify the water transmission zone. Information from well logs, water table levels, and topography are used to delineate the recharge area.*

e) <u>Soil sampling</u>. When collecting soil, it is important to combine several samples from various parts of a field to get an average sample. In a homogeneous or uniform field, ten samples taken from different locations should be adequate. Depth of sampling is important. Saline and sodic soils should be sampled from 0-6 inches, 6-12 inches, and 12-24 inches. These three depth increments should be analyzed separately. Samples should be sent to qualified commercial or university laboratories for analysis.

CONTROLLING WATER IN THE RECHARGE AREA

1. Because of the uniqueness of soils, an onsite investigation must be made to document actual conditions and gather supporting data before starting to develop plans to resolve the salt problem. The initial review should include a review onsite with the operator, collecting historical information about the development of the seep and cropping history of the suspected recharge area.

2. If monitoring wells are installed, monthly elevations will be obtained on all investigation wells to assist in determining movement and source of groundwater. This will also aid in the identification of the recharge area. Monitoring should be completed until the water table levels are determined and then continued seasonally throughout the life of the practice until the seep is reclaimed.

3. Plant deep-rooted perennials such as alfalfa to dry the soil profile in the recharge area where depth to the impermeable layer is more than five feet. Deep-rooted perennial forages must be seeded on at least 80 percent of the recharge area. Bleeded area should include the acreage of highest water table elevation within the defined recharge area.

4. When a seep has been identified, flexible or annual cropping may be used to dry the recharge area if the soils are five feet or less in depth to the impermeable layer (limited to 20 percent of the recharge area).

5. Select plants from Tables 3 and 4 that remove excess moisture from the recharge area. To establish vegetation, properly use planting dates and seedbed preparation procedures found in the FOTG, Section IV, Pasture and Hayland Planting (512).

6. After the groundwater has been removed from the recharge area, an intensive cropping system must be applied to prevent the buildup of new water. See ìFlex Croppingî in the FOTG, Section IV, Conservation Cropping Sequence (328). Crops should be grown in sequential order with increasing rooting depths, until the depth and amount of soil-water removed exceeds soil-water recharge. Summer fallow should only be used when needed (i.e., when less than adequate moisture exists to produce a crop at planting time).

7. An appropriate soil fertility program must be implemented if flex cropping or annual cropping is utilized to ensure a successful crop and maximizing the crops rooting ability and moisture extraction [see FOTG, Section IV, Nutrient Management (590)].

8. Maintenance measures such as mowing, clipping, and removing excess vegetation must be completed to maintain vigorous growth. In some cases, fertilization may be required to invigorate vegetative growth.

ESTABLISHING PLANTS IN THE SALINE SEEP

1. An Electrical Conductivity (EC) test must be made of the plow layer or top few inches of the soil. This information is used to determine what plant materials can be established in the seep (see Table 1).

2. Before reclaiming a saline seep area, the flow of water from the recharge area must be reduced so that the depth of the water table in the area of the seep is low enough to prevent salts from moving up by capillary action into the rooting zone. A general rule of thumb is that if the depth of the water table in the seep exceeds 5 feet, reclamation procedures to remove salts from the root zone can proceed.

3. To control the buildup of salt on the soil surface, vegetation should be established in the seep area as soon as it starts to dry.

4. Weeds and grasses including Kochia and foxtail barley must be controlled, preferable by herbicide, prior to vegetative establishment. Mechanical seedbed preparation may be implemented if the site is not too wet.

5. Seed should be planted with a drill whenever possible. Wet soils may be planted by broadcasting after weed control has been successful. Wet sites may also be planted by drilling on frozen ground (frost seeding). Seeding rates should follow Table 6, Seeding Rates for Salinity Management.

6. Mixtures of forages should be seeded in the seep rather than a single species in the salt-affected area.

7. If the water table is above four feet, mow and remove all vegetation in the fall to prevent excess snow accumulation and rise of water table. If the water table is below four feet, vegetation can be left to catch snow. Resulting snowmelt will leach the salt downward through the soil improving growth.

SODIC SOILS

1. Identification of sodic conditions is imperative. Soil tests, as outlined in ìsoil samplingî under the identification of saline recharge area, must be completed. Soil analysis should include pH, EC, Na, Ca, Mg, and SAR of saturated paste extract.

2. The presence of lime (free calcium carbonate) in the soil allows the widest selection of amendments. To test for this, a simple procedure can be followed by taking a spoonful or clod of soil and dropping a few drops of muriatic or sulfuric acid on it. If bubbling or fizzing occurs, this indicates the presence of carbonates or bicarbonates. If the soil contains lime, any of the amendments listed in Table 2 may be used. If lime is absent, select only those amendments containing soluble calcium.

Table 2. Commonly Used Materials and Their Equivalent Amendment Values

	Tons of Amendment Equivalent to:	
Material (100% Basis)	*1 Ton Pure Gypsum*	*1 Ton of Soil Sulfur*
Gypsum	*1.00*	*5.38*
Soil Sulfur	*0.19*	*1.00*
Sulfuric acid (conc.)	*0.61*	*3.20*
Ferric sulfate	*1.09*	*5.85*
Lime sulfur (22%S)	*0.68*	*3.65*
Calcium chloride	*0.86*	——
Calcium nitrate	*1.06*	——
Aluminum sulfate	*1.29*	*6.94*

3. For specific recommendations as to the amount of amendment(s) a producer may need to apply to correct sodic soil hazards, the producer should contact a soil fertility specialist to obtain recommendations based on soil analysis.

CONSIDERATIONS FOR SODIC SOILS

Unlike saline soils, sodium does not impair the uptake of water by plants but does impair the infiltration of water into the soil. The growth of plants is, thus, affected by an unavailability of soil water. The reduction in infiltration of water can usually by attributed to surface crusting, the dispersion and migration of clay into soil pores, and the swelling of expandable clays.

Sodic soils, unlike saline soils, which generally have normal physical properties, are typical where physio-chemical reactions cause the slaking of aggregates and the ìswelling of clay minerals, leading to reduced permeability, crusting, and poor tilth. Sodic soils contain sufficient exchangeable solution to interfere with the growth of most crops. These soils are commonly termed alkali, black alkali, and slick spots. The darkened appearance is caused by the dispersed and dissolved organic matter deposited on the soil surface by evaporation.

Adsorbed sodium causes disintegration of the soil aggregates, dispersing the soil particles and reducing the large pore spaces. This makes water flow through the surface layers difficult since the soil becomes almost impervious to water.

On non-calcareous soils, treatment must be made with gypsum or other soluble calcium salts. On calcareous soils, treatment may be with gypsum or acidifying materials including sulfuric acid, sulfur, and iron and aluminum sulfates. Calcium replaces sodium on the clay surface and helps to bring about a better physical condition that will allow sodium and excess salts to be leached.

Organic materials such as manure, crop residues, etc., may be helpful by providing a better physical condition for leaching. Reclamation of sodic land must be measured in terms of the time and cost of the treatment, the value of the crop to be raised and the ultimate value of the land. Because of the special conditions which may exist, consulting a soil specialist for specific recommendations to fit the individual case is advisable.

Reclamation of sodium-affected soil usually involves replacing exchangeable Na+ with CA^{2+}*. Controlling sodicity on dryland soils is generally accomplished using treatments such as agricultural amendments and organic matter to maintain soil permeability and tilth. The effectiveness of amendments in reclaiming sodic soils depends largely on their dissolution properties.*

Amendments most commonly used to provide soluble Ca include gypsum, sulfuric acid, and sulfur, due to their relatively low cost and effectiveness. Chemical amendments may improve water penetration caused by excessive sodium, if the texture of the soil, compaction, or water-restricting layers is not the cause of low permeability.

<u>GYPSUM</u>. Due to its solubility, low cost, and availability, gypsum is the most commonly used amendment for reclaiming sodium-affected soil. Gypsum must dissolve to effect reclamation. Generally soil water penetrates too slowly to reclaim sodium-affected soils in a single leaching. Thus, sodium-affected soil normally can only be reclaimed to a limited depth the first year. This may permit the production of a shallow-rooted crop.

<u>ACIDS AND SULFUR</u>. Sulfuric acid is an amendment that treats sodium-affected soils. The acid reacts with soil calcium carbonate to form gypsum or calcium chloride. Sulfur requires an initial phase of microbiological oxidation to produce gypsum. Concentrated acid may be applied directly to the surface of the soil, which tends to give best results, or acid may be applied by chiseling into the soil in bands. It should be noted that acid is highly corrosive and should not be added to water that will pass through metal of concrete irrigation systems.

For elemental sulfur application, dust poses a problem. This can be overcome by using conventional fluid fertilizer equipment to apply water suspensions containing 55% to 60% sulfur or granulated S.

CALCIUM CHLORIDE. Calcium chloride is generally too expensive to compete with other amendments but may be available an an industrial waste product. Calcium chloride is highly soluble making it a more efficient amendment than gypsum.

CONSIDERATIONS

Salinization problems in Montana are caused by geology, increased precipitation during certain periods, and farming practices that allow water to move beyond the root zone and into the subsoil of saline geologic formations.

Seep formation begins with a root zone filled to its water holding capacity. For example, during a 21-month fallow period, precipitation exceeds the storage capacity of the soil. Some of the water runs off the surface, some evaporates, and the rest moves into the soil. Once the soil is filled to field capacity, any additional water that moves through the root zone may contribute to seepage. Water percolation through salt-laden strata dissolves salts and eventually forms a salt-laden water table above an impermeable or slowly permeable layer. The underground salt-laden water moves downslope and dissolves more salts, until it eventually discharges at the soil surface.

The discharge water evaporates, concentrating salt on or near the soil surface. As a result, crop growth in the affected area is reduced or eliminated and the soil is too wet to be farmed.

Salt-affected sites are somewhat unique in that they have variations in levels of salinity, different kinds of salts, differences in climatic patterns, and varying soil materials. Salt-affected soils have been internationally classified into general categories. Salt-affected soils of primary concern in Montana, along with their descriptive parameters, are listed below:

a) Saline Soils
  EC >4 mmhos/cm at $25^{o}C$
  SAR 0-12
  pH <8.5

b) Saline-Sodic Soils
  EC >4 mmhos/cm at $25^{o}C$
  SAR >12
  pH usually <8.5

c) Sodic Soils
  EC <4 mmhos/cm at $25^{o}C$
  SAR >12
  pH usually >8.5

d) Saline-Alkaline Soils
  EC >4 mmhos/cm at $25^{o}C$
  SAR >15
  pH <8.5

The saline soils are commonly flocculated due to the presence of excess salts and the absence of significant amounts of exchangeable sodium. As a consequence infiltration rates and permeability are equal to or higher than that of similar non-saline soils.

Saline-sodic soils are similar in appearance to the saline soils as long as excess salts are present. However, if leaching has occurred or been utilized, most of the excess soluble salts may be removed causing soil particles to disperse. The soil then becomes unfavorable for infiltration and the internal movement of water. The soil will also become difficult to till.

Sodic soils have dark-colored surfaces and are highly dispersed. These soils have low infiltration characteristics and poor permeability.

Changes in land use, brought about by plowing the native range and subsequent introduction of the crop-fallow system, disrupted the original hydrologic balance of the land and are largely responsible for salinization in Montana. Several conditions or combinations of conditions contribute water that causes salt problems.

1. Fallow. During the fallow period, water removed by the previous crop is replenished. When the amount of water used by the previous crop has been recharged by precipitation, any additional water entering the soil moves to the water table and often resurfaces downslope as a seep.

2. High Precipitation Periods. Infiltration and subsequent percolation may exceed the water holding capacity of the root zone during periods of high rainfall (or snowmelt) causing considerable quantities of water to move to the water table.

3. Poor Surface Drainage. Runoff water can collect in shallow land depressions. Some of this water infiltrates into the soil, raising the water table. The water may also flow downslope to eventually resurface as a seep.

4. Snow accumulation. Windbreaks, roadways, railroadways, vegetative filter strips, and other wind-protected areas can collect large amounts of snow. Under some conditions, this snow can contribute significant amounts of water to the water table. If barriers are found to be contributing water to discharge area, the cropping system should be altered to use the additional water or the barrier should be modified or removed

5. Gravelly and Sandy Soils. Water infiltrates rapidly on these soils, which have limited water holding capacities. These areas should be cropped annually or seeded to a perennial crop.

6. Drainageways. Surface and subsurface water flows may be disrupted by the soil texture changes (i.e., clay dikes, dams), topography, or geology, causing the buildup of salt-laden groundwater that could eventually surface as a seep. The fresh water carried by natural drainageways keeps the area wet, perpetuating seeps. Improving the natural drainage will help alleviate the problem.

7. Constructed Ponds and Dugouts that Leak Water. Seeps are often severe downslope from these structures. If the stored water is salty, these structures should be removed.

8. Artesian Water. Drilling through consolidated material or shale layers may encounter confined saline water systems under pressure. The holes may release artesian water that flows to the surface to form or contribute to a seep area. These holes should be carefully plugged. [See FOTG, Section IV, Well Decommissioning (351)].

9. Roadbeds across Natural Drainageways. Construction of roads and railroads disrupt or restrict the normal underground lateral waterflow. Improperly installed or plugged culverts may cause the water table to rise to the surface, causing a salinized area. Gravel fills to a depth of at least five feet below the roadbed will preserve and enhance subsurface flow.

10. Crop Failure. Crop loss as a result of poor stand establishment, hailstorms, winterkill, diseases, insects, and low fertility may cause incomplete use of stored soil water. If this land is fallowed the following year, the water storage capacity is limited. This will cause extra water to move below the root zone to aggravate the seep problem.

Since seeps are caused by water moving below the root zone in the recharge area, there can be no permanent solution to the seep area unless control measures are applied to the recharge area. There are two general procedures for managing seeps; 1) by agronomically using the water before it percolates below the root zone, and 2) by mechanically draining ponded surface waters where possible before it infiltrates.

AGRONOMIC MEASURES:

1. Annual cropping or flexible cropping.

Flexible cropping is the seeding of a crop when stored soil-water and rainfall probabilities are favorable for a satisfactory yield or fallowing when prospects are unfavorable [see FOTG, Section IV, Conservation Cropping Sequence (328)]. Safflower, sunflower, and canola are crops that may be seeded in rotation with small grains to use deep subsoil water not used by cereals (see Table 3, Rooting Depth and Soil Water Depletion of Various Crops).

2. Perennial Vegetation (Alfalfa and grasses).

Seeding alfalfa in a recharge area is often the quickest, most effective way to dry the deep subsoil and stop water flow to a seep area. Grasses may also be seeded in the recharge area. They are most effective where the depth to an impermeable layer is less than 15 feet.

Table 3. Rooting Depth and Soil Water Depletion of Various Crops[1/]

Crop	*Rooting Depth (ft.)*	*Soil Water Depletion (in.)*
Safflower	*7*	*10*
Sunflower	*6*	*7*
Oriental Mustard	*5*	*7*
Flax	*5*	*7*
Yellow Mustard	*4*	*6*
Turnip Rape	*5*	*7*
Brown Mustard	*5*	*7*
Argentine Rape	*4*	*7*
Winter Wheat	*6*	*7*
Barley	*5*	*6*
Spring Wheat	*4*	*6**
Corn	*4*	*4**
Sweet Clover		
1st year	*6*	*11**
2nd year	*9*	*16**
Peas	*<4*	*<4**
Lentils	*<4*	*<4**

[1/]Actual results will vary depending on soil characteristics, soil climatic conditions, and management.

**designates soil water use (average annual water used by the plant) rather than net soil water depletion.*

3. Applying high rates of manure.

Using 20 to 30 tons per acre, increases fertility, organic matter content, and water holding capacity of the soil, making more water available to the plant even though salts may be present. Manure mulch also reduces evaporation and the concentration of salts at the surface of the soil.

4. Drainage.

Where possible, surface drains can be installed to prevent the temporary ponding of surface water. Drainageways under roadways should be kept clear of debris and sediment so that the site does not serve as a contributing or recharge area. As usual, all state and federal guidelines and restrictions must be followed when considering drainage.

5. Stubble and Vegetative Snow Trapping.

Grass barriers, standing stubble, filter strips, and combinations of these are excellent ways to trap and hold snow on the land and provide uniform snow distribution. These practices reduce snow blowing from fields and increase soil-water storage in the root zone, providing a greater opportunity for successful recropping. The additional water storage resulting from grass barriers, filter strips, and standing stubble should be utilized by more intensive cropping. If it is not utilized, it may increase water movement through the soil and contribute to the seep.

Table 4. Rooting Depth and Net Soil Water Depletion of Various Grasses and Forages[1/]

Species	*Rooting Depth (ft)*	*Net Soil Water Depletion*
Alfalfa (average)	***20***	***28 in.***
Altai wildrye	***14***	***(high)***
Basin wildrye	***18***	***26 in.***
Cicer milkvetch	***15***	***23 in.***
Crested wheatgrass	***13***	***16 in.***
Green needlegrass	***15***	***23 in.***
Inter. wheatgrass	***15***	***29 in.***
Pub. wheatgrass	***15***	***22 in.***
Russian wildrye grass	***10***	***19 in.***
Sainfoin	***14***	***23 in.***
Slender wheatgrass	***15***	***22 in.***
Tall Fescue	***15***	***25 in.***
Tall wheatgrass	***9***	***17 in.***
Western wheatgrass	***11***	***20 in.***

[1/]Results will vary depending on soil characteristics, climatic conditions, and management.

Water Quantity

CONSIDER:

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

Water Quality

CONSIDER:

1. Potential for transfer of salinity conditions to another location where surface or subsurface drains are used.

2. Effects of erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances, including salts, that could be carried by runoff.

3. Test the soil water extract of the soil surface and potential root zone to determine the presence and concentration of saline or sodic substances. Refer to National Engineering Handbook, Section 16, Chapter 4, for guidance on how electrical conductivity levels affect potential yields.

4. Map the affected area.

5. Determine the relationship of the ground surface topography and the water table contours in and adjacent to the problem area. One suggested method involves installing nine (three rows of three) auger hole observation wells for water table measurements. Additional wells may be needed to adequately define the recharge area.

6. The potential causes or sources of excess salts on non-irrigated land include inadequate drainage, inadequate leaching, indigenous soil salts, and inundation by and evaporation of salt-laden waters. In none of the above factors is the cause of salinity, other possibilities should be considered, such as excessively applied fertilizer or manure.

Tables 5 and 6 continued on Page 11.

Table 5. Relative Salt Tolerance of Herbaceous Crops

Common Name	*Threshold*	*Upper Limits*
Crops	*dS/m*	*dS/m*
Barley	*8*	*16*
Corn	*3*	*6*
Oats	*4*	*6*
Safflower	*6*	*10*
Sugarbeet	*7*	*12*
Wheat	*6*	*13*
Forages/wet		
Beardless wildrye	*12*	*26*
Tall wheatgrass	*12*	*26*
Hybrid wheatgrass	*10*	*24*
Slender wheatgrass	*10*	*23*
Tall fescue	*7*	*18*
Western wheatrass	*6*	*16*
Strawberry clover	*6*	*16*
Creeping foxtail	*5*	*12*
Meadow bromegrass	*4*	*10*
Cicer milkvetch	*4*	*10*
Orchardgrass	*3*	*8*
Forages/dry		
Russian wildrye	*12*	*24*
Tall wheatgrass	*12*	*24*
Altai wildrye	*10*	*20*
Slender wheatgrass	*10*	*20*
Crested wheatgrass	*6*	*16*
Pubescent wheatgrass	*6*	*12*
Interm. wheatgrass	*6*	*12*
Smooth bromegrass	*5*	*10*
Yellow sweetclover	*5*	*10*
Birdsfoot trefoil	*5*	*10*
Alfalfa	*4*	*8*
Natives		
Nuttailís alkaligrass	*14*	*30+*
Alkali sacton	*14*	*26*
Beardless wildrye	*12*	*26*
Alkali cordgrass	*12*	*26*
Alkali bluegrass	*12*	*24*
Slender wheatgrass	*10*	*22*
Plains bluegrass	*10*	*20*
Western wheatgrass	*6*	*16*
Thickspike wheatgrass	*6*	*14*

Table 6. Seeding Rates for Salinity Management

	Seeding Rate [2/]	
Species [1/]	*Drilled*	*Broadcast*
Beardless Wildrye	*7*	*14*
Tall Wheatgrass	*14*	*28*
Altai Wildrye	*12*	*24*
Hybrid Wheatgr.	*8*	*16*
Slender Wheatgr.	*8*	*16*
Interm. Wheatgr.	*7*	*14*
Orchardgrass	*4*	*8*
Pubesc. Wheatgr.	*7*	*14*
Smooth Brome	*5*	*10*
Tall Fescue	*6*	*12*
Russian Wildrye	*7*	*14*
Western Wheatgr.	*7*	*14*
Creeping Foxtail	*3*	*6*
Crested Wheatgr.		
Fairway	*4*	*8*
Standard	*5*	*10*
Desert Wheatgr.	*7*	*14*
Siberian Wheatgr.	*7*	*14*
Birdsfoot Trefoil	*5*	*10*
Alfalfa	*5*	*10*
Cicer Milkvetch	*8*	*16*
Barley	*80*	*80*
Wheat	*60*	*60*
Oats	*60*	*60*

[1/] If species are not listed, use FOTG, Section IV, Pasture and Hayland Planting (512) rates.
[2/] All seeding rates are lbs. PLS/ac.

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Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.